Benha University | Antennas &Wave Propagation | Electrical Eng. Dept.
Faculty of Engineering | 4^{th} year communication
Shoubra | 2013-2014

Sheet (1) - Solution

1. Define antenna, and State different types of antenna.

Antenna is defined as

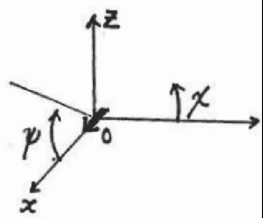
A transducer designed to transmit and receive electromagnetic waves, it converts signals on electric circuits (V&I) to EM waves (E&H) radiate in space and vise versa.

Antenna can be categorized by:

- ❑ Narrow band versus broadband
- ❑ Size in comparison to the wavelength (e.g., electrically small antennas)
- ❑ Omni-directional versus directional antennas
- ❑ Polarization (linear, circular, or elliptic)
- ❑ **Antenna Types by Physical Structure**
  - Wire antennas
  - Aperture antennas
  - Microstrip antennas
  - Antenna arrays
  - Reflector antennas

2. A horizontal infinitesimal electric dipole of constant current I_o is placed symmetrically about the origin and directed along the x-axis. Derive the far-zone fields radiated by the dipole.

$$\sin\psi = \sqrt{1-\cos^2\psi} = \sqrt{1-|\hat{a}_x\cdot\hat{a}_r|^2}$$
$$= \sqrt{1-(\sin\theta\cdot\cos\phi)^2}$$



In far-zone fields

$$E_\psi \simeq j\eta\frac{kI_o\cdot l e^{-jkr}}{4\pi r}\cdot\sin\psi = j\eta\frac{k\cdot I_o l e^{-jkr}}{4\pi r}\cdot\sqrt{1-(\sin\theta\cdot\cos\phi)^2}$$

$$H_\chi \simeq j\frac{kI_o l e^{-jkr}}{4\pi r}\cdot\sin\psi = \frac{E_\psi}{\eta}$$

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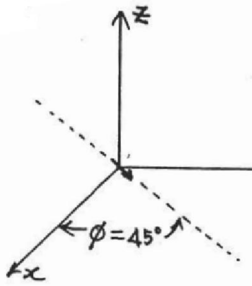
3. Repeat Problem 2 for a horizontal infinitesimal electric dipole directed along the y-axis.

As problem 2, but here $\cos\psi = \lvert \hat{a}_y \cdot \hat{a}_r \rvert = \sin\theta \sin\phi$

4. An infinitesimal electric dipole is centered at the origin and lies on the x-y plane along a line which is at an angle of 45° with respect to the x-axis. Find the far-zone electric and magnetic fields radiated. The answer should be a function of spherical coordinates.



$$E_\psi = j\eta \frac{k I_0 l}{4\pi r} e^{-jkr} \sin\psi$$

$$H_\chi = j \frac{k I_0 l}{4\pi r} e^{-jkr} \sin\psi$$

Convert ψ to spherical coordinates

$$\sin^2\psi = 1 - \cos^2\psi = \sqrt{1 - \left(\frac{\hat{a}_x + \hat{a}_y}{\sqrt{2}} \cdot \hat{a}_r\right)^2}$$

$$\leftarrow \frac{\hat{a}_x + \hat{a}_y}{\sqrt{2}} \cdot \hat{a}_r = \left(\frac{\hat{a}_x}{\sqrt{2}} + \frac{\hat{a}_y}{\sqrt{2}}\right) \cdot \left(\hat{a}_x \sin\theta\cos\phi + \hat{a}_y \sin\theta\sin\phi + \hat{a}_z \cos\theta\right)$$

$$= \frac{\sin\theta\cos\phi}{\sqrt{2}} + \frac{\sin\theta\sin\phi}{\sqrt{2}} = \frac{1}{\sqrt{2}}\sin\theta(\cos\phi + \sin\phi)$$

Thus

$$E_\psi = j\eta \frac{k I_0 l}{4\pi r} e^{-jkr} \sqrt{1 - \tfrac{1}{2}\left[\sin^2\theta(\cos\phi + \sin\phi)^2\right]}$$

$$H_\chi = j \frac{k I_0 l}{4\pi r} e^{-jkr} \sqrt{1 - \tfrac{1}{2}\left[\sin^2\theta(\cos\phi + \sin\phi)^2\right]}$$

(REPORT)

1. Describe radiation mechanism for single wire and two wires antenna.
2. Why the infinitesimal electric dipole is not a practical antenna.

Good Luck

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